Climate Change and Flood Control Operations in the Sacramento Basin

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Sacramento District

Decrease in Spring Runoff

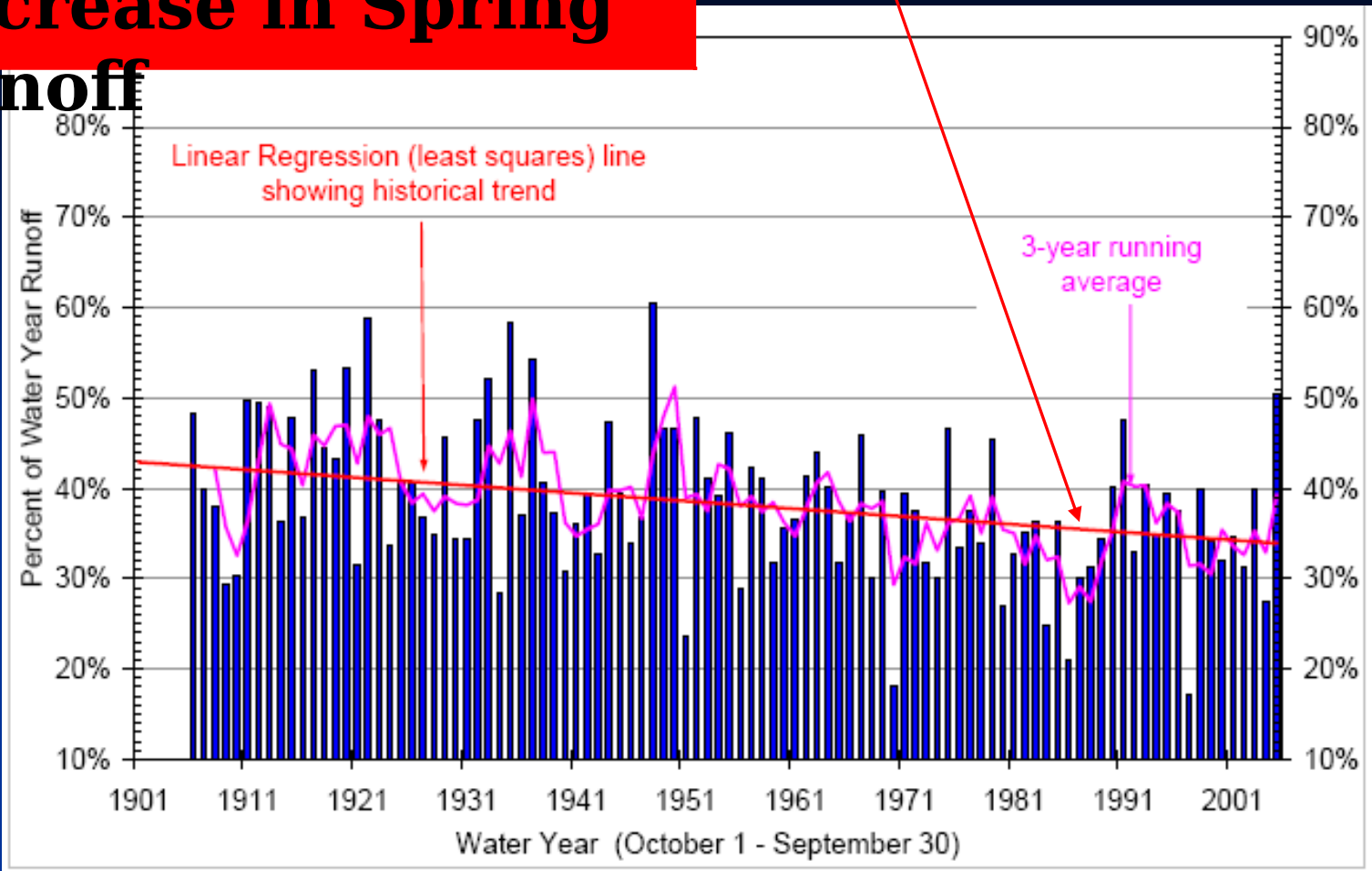


Figure 2-13 Annual April through July Unimpaired Runoff for Four Sacramento Valley Rivers Compared to Total Unimpaired Annual Runoff*

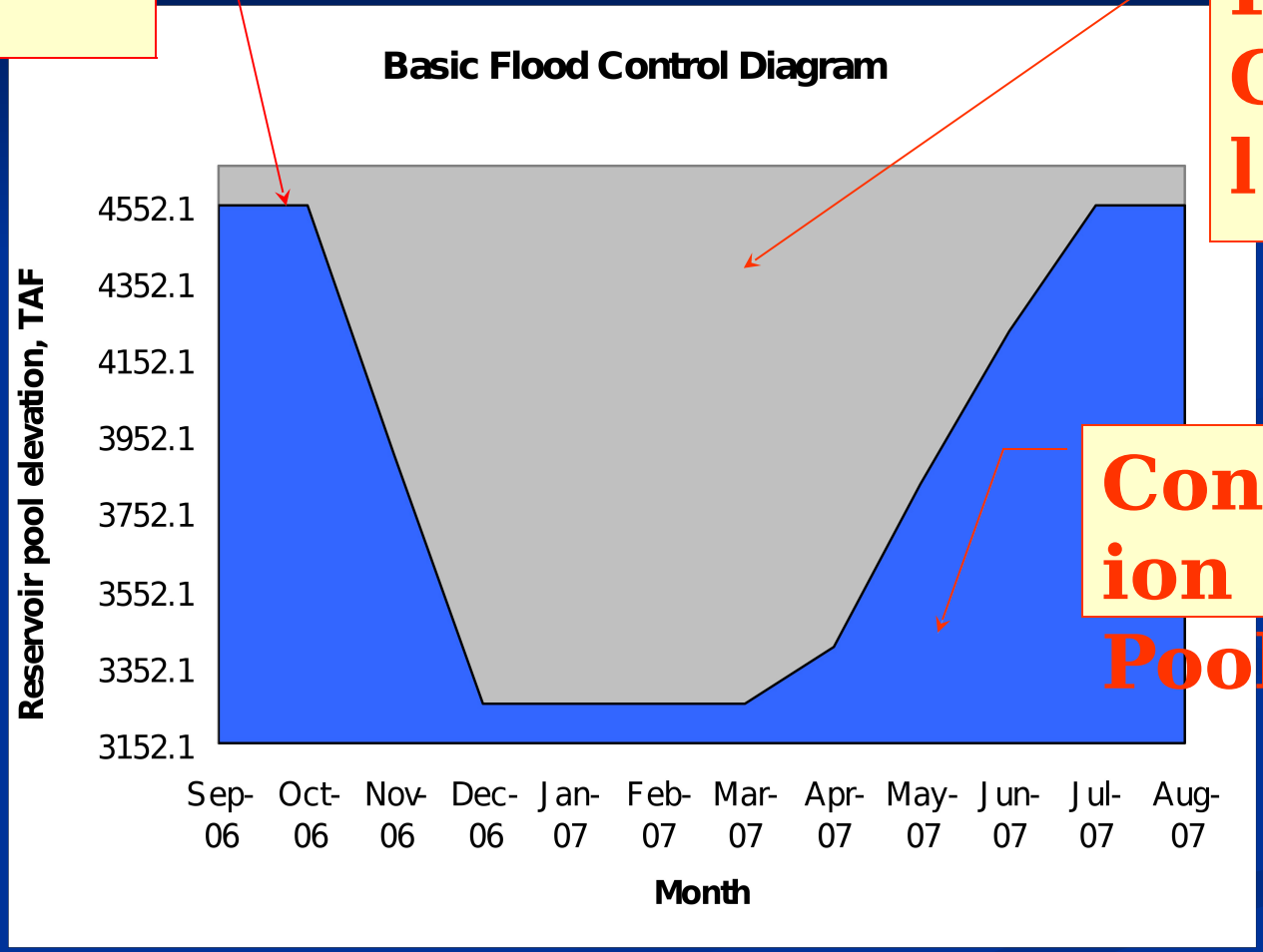
* Based on the flows of four rivers in the Sacramento Valley; Sacramento River at Bend Bridge (near Red Bluff), Feather River into Lake Oroville, Yuba River at Smartville, and American River below Lake Folsom.

Conceptual rule curve

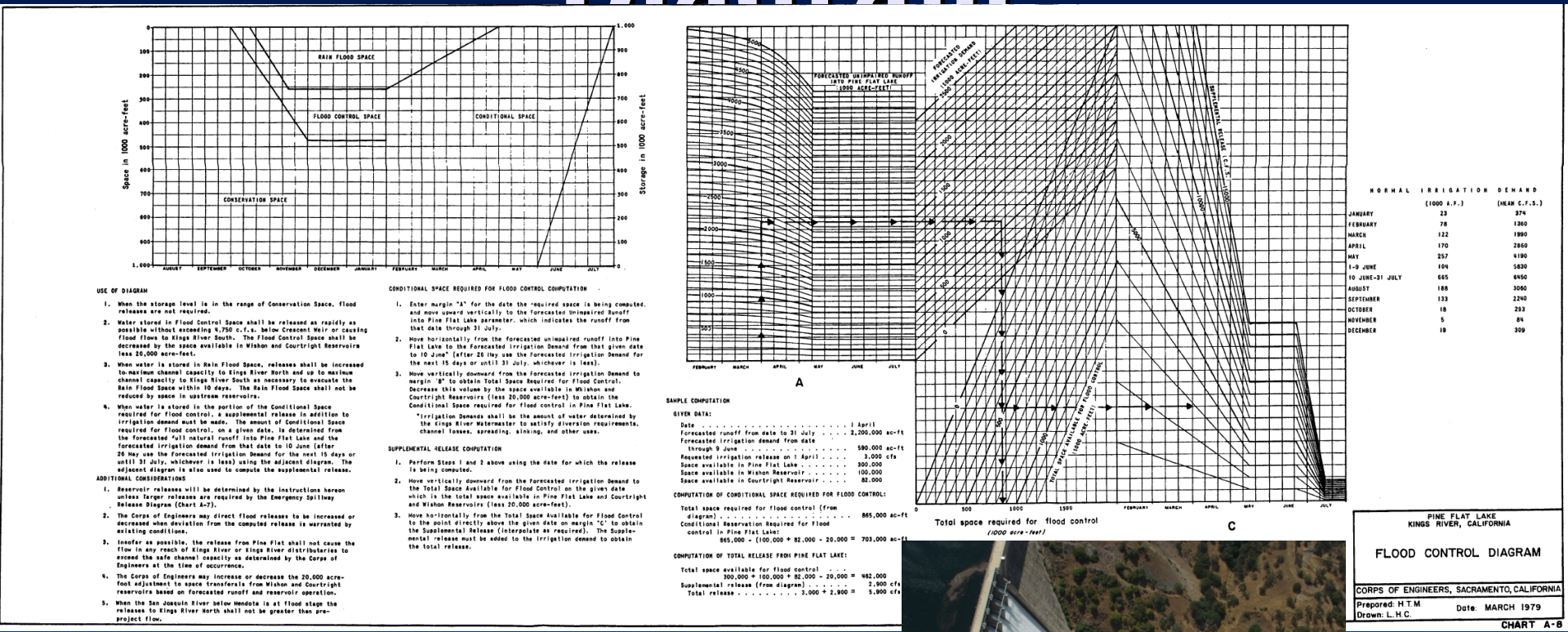
Rule Curve

Flood Control Pool

Conservation Pool



Pine Flat Flood Control Diagram


RAIN FLOOD SPACE
FLOOD CONTROL SPACE
CONDITIONAL SPACE
CONSERVATION SPACE
Space in 1000 acre-feet
Storage in 1000 acre-feet
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
USE OF DIAGRAM
1. When the storage level is in the range of Conservation Space, flood releases are not required.
2. Water stored in Flood Control Space shall be released as rapidly as possible without exceeding 4,750 c.f.s. below Crescent Weir or causing flood flows to Kings River South. The Flood Control Space shall be decreased by the space available in Wishon and Courtright Reservoirs less 20,000 acre-feet.
3. When water is stored in Rain Flood Space, releases shall be increased to maximum channel capacity to Kings River North and up to maximum channel capacity to Kings River South as necessary to evacuate the Rain Flood Space within 10 days. The Rain Flood Space shall not be reduced by space in upstream reservoirs.
4. When water is stored in the portion of the Conditional Space required for flood control, a supplemental release in addition to irrigation demand must be made. The amount of Conditional Space required for flood control, on a given date, is determined from the forecasted full natural runoff into Pine Flat Lake and the forecasted irrigation demand from that date to 10 June (after 26 May use the forecasted irrigation demand for the next 15 days or until 31 July, whichever is less) using the adjacent diagram. The adjacent diagram is also used to compute the supplemental release.
ADDITIONAL CONSIDERATIONS
1. Reservoir releases will be determined by the instructions hereon unless larger releases are required by the Emergency Spillway Release Diagram (Chart A-7).
2. The Corps of Engineers may direct flood releases to be increased or decreased when deviation from the computed release is warranted by existing conditions.
3. Insofar as possible, the release from Pine Flat shall not cause the flow in any reach of Kings River or Kings River distributaries to exceed the safe channel capacity as determined by the Corps of Engineers at the time of occurrence.
4. The Corps of Engineers may increase or decrease the 20,000 acre-foot adjustment to space transferals from Wishon and Courtright reservoirs based on forecasted runoff and reservoir operation.
5. When the San Joaquin River below Mendota is at flood stage the releases to Kings River North shall not be greater than pre-project flow.
CONDITIONAL SPACE REQUIRED FOR FLOOD CONTROL COMPUTATION
1. Enter margin "A" for the date the required space is being computed, and move upward vertically to the Forecasted Unimpaired Runoff into Pine Flat Lake parameter, which indicates the runoff from that date through 31 July.
2. Move horizontally from the forecasted unimpaired runoff into Pine Flat Lake to the Forecasted Irrigation Demand from that given date to 10 June* (after 26 May use the Forecasted Irrigation Demand for the next 15 days or until 31 July, whichever is less).
3. Move vertically downward from the Forecasted Irrigation Demand to margin "B" to obtain Total Space Required for Flood Control. Decrease this volume by the space available in Whishon and Courtright Reservoirs (less 20,000 acre-feet) to obtain the Conditional Space required for flood control in Pine Flat Lake.
*Irrigation Demands shall be the amount of water determined by the Kings River Watermaster to satisfy diversion requirements, channel losses, spreading, sinking, and other uses.
SUPPLEMENTAL RELEASE COMPUTATION
1. Perform Steps 1 and 2 above using the date for which the release is being computed.
2. Move vertically downward from the forecasted irrigation Demand to the Total Space Available for Flood Control on the given date which is the total space available in Pine Flat Lake and Courtright and Wishon Reservoirs (less 20,000 acre-feet).
3. Move horizontally from the Total Space Available for Flood Control to the point directly above the given date on margin "C" to obtain the Supplemental Release (interpolate as required). The Supplemental release must be added to the irrigation demand to obtain the total release.
FORECASTED UNIMPAIRED RUNOFF INTO PINE FLAT LAKE (1000 ACRE-FEET)
FORECASTED IRRIGATION DEMAND (1000 ACRE-FEET)
SUPPLEMENTAL RELEASE C.F.S.
TOTAL SPACE AVAILABLE FOR FLOOD CONTROL (1000 ACRE-FEET)
A
B
C
Total space required for flood control (1000 acre-feet)
SAMPLE COMPUTATION
GIVEN DATA:
Date . . . . . 1 April
Forecasted runoff from date to 31 July . . . . 2,200,000 ac-ft
Forecasted irrigation demand from date through 9 June . . . . . 590,000 ac-ft
Requested irrigation release on 1 April . . . . 3,000 cfs
Space available in Pine Flat Lake 300,000
Space available in Wishon Reservoir 100,000
Space available in Courtright Reservoir 82,000
COMPUTATION OF CONDITIONAL SPACE REQUIRED FOR FLOOD CONTROL:
Total space required for flood control (from diagram) . . . . . 865,000 ac-ft
Conditional Reservation Required for Flood control in Pine Flat Lake:
865,000 - (100,000 + 82,000 - 20,000 = 703,000 ac-ft
COMPUTATION OF TOTAL RELEASE FROM PINE FLAT LAKE:
Total space available for flood control . . . 300,000 + 100,000 + 82,000 - 20,000 = 462,000
Supplemental release (from diagram) . . . . . 2,900 cfs
Total release . . . . . 3,000 + 2,900 = 5,900 cfs
NORMAL IRRIGATION DEMAND
(1000 A.F.) (MEAN C.F.S.)
JANUARY 23 374
FEBRUARY 78 1360
MARCH 122 1990
APRIL 170 2860
MAY 257 4190
1-9 JUNE 104 5830
10 JUNE-31 JULY 665 6450
AUGUST 188 3060
SEPTEMBER 133 2240
OCTOBER 18 293
NOVEMBER 5 84
DECEMBER 19 309
PINE FLAT LAKE
KINGS RIVER, CALIFORNIA
FLOOD CONTROL DIAGRAM
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: H.T.M. Date: MARCH 1979
Drawn: L.H.C.
CHART A-8

Typical snowmelt influenced rule

How were rule curves made?

- 1959 Manual
- Historical hydrologic data ranging from early 1900s to 1970s
- Functional objectives of the dam
- Trial and error

Why revise these curves?

- More data available
- Current trends are different
- Projected climate changes

Methodology

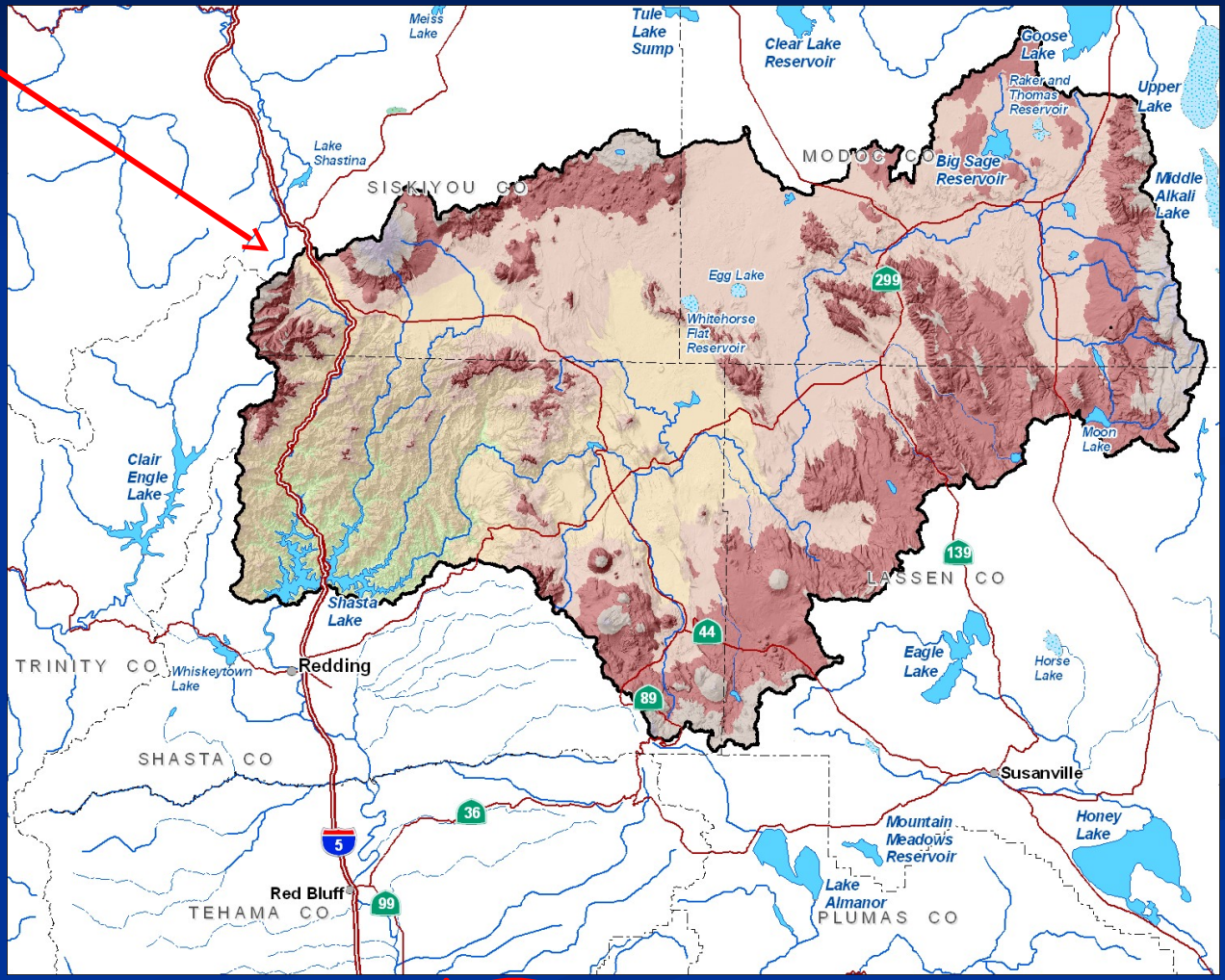
- Analyze 22 GCM simulations for 2030 projected temperature and precipitation ranges under two climate scenarios
- Determine 10th, 50th and 90th temperature and precipitation percentiles by subbasin
- Generate reservoir inflows using perturbed temperature and precipitation input using NWS-RFS
- Test flood control curves using ResSim

Major Central Valley watersheds

Mean basin elevation

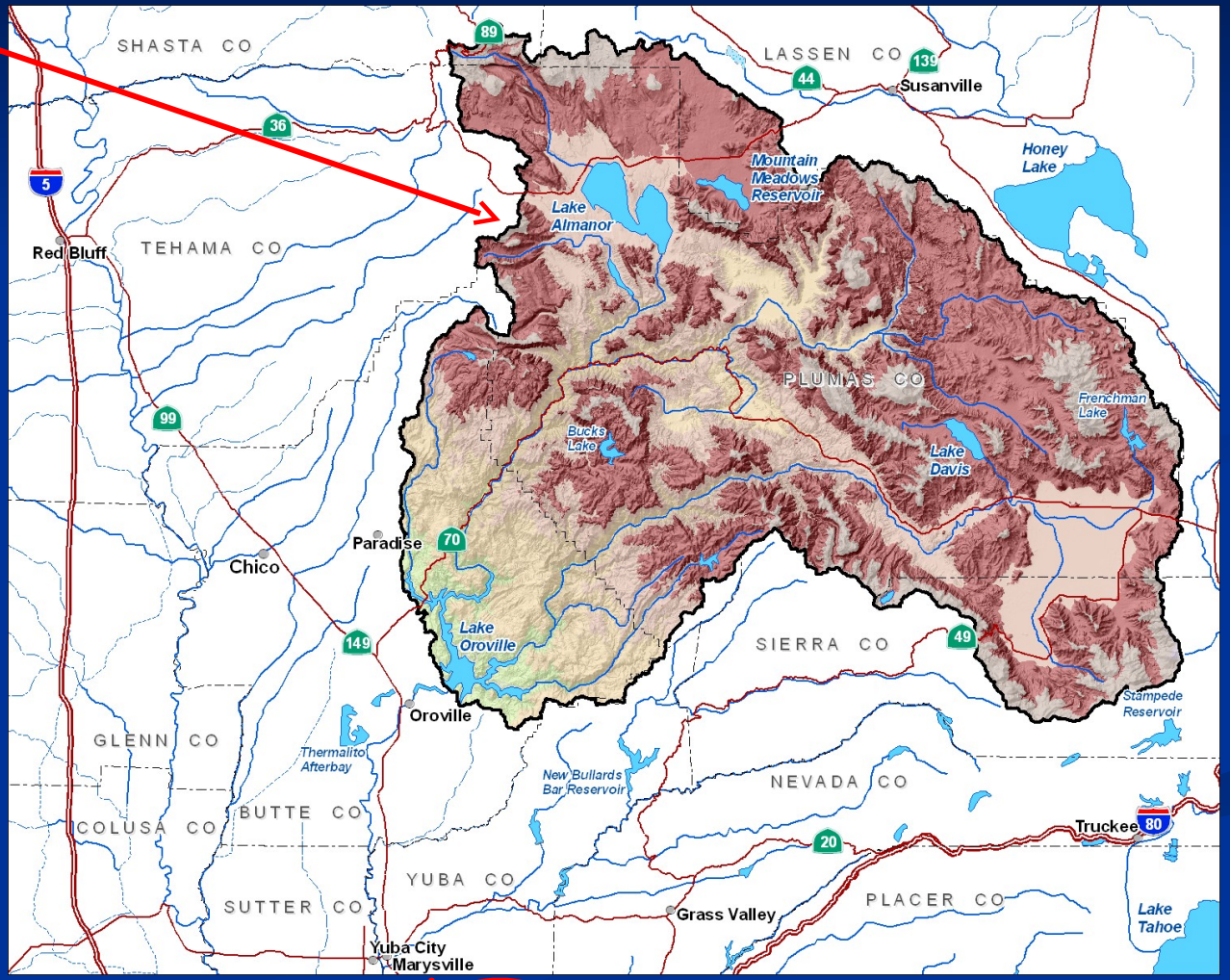
- Shasta: 1400 m
- Oroville: 1550 m
- New Bullards Bar: 1500 m

Shasta



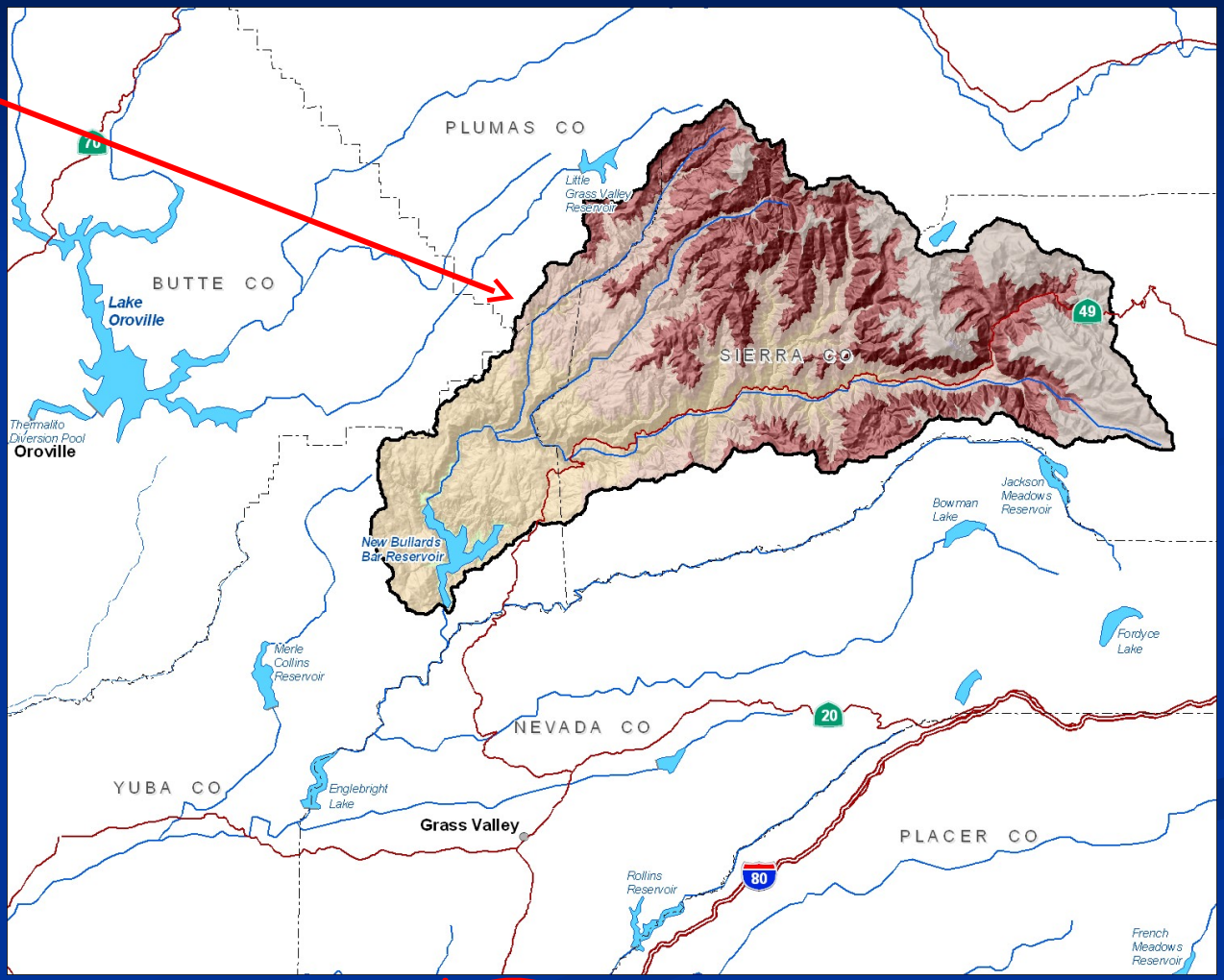
- Elevation range: 178-4300 m
- 33% between 1525-1980m
- Basin area: 1,711,982 ha
- Storage: 5.6×10^9 m^3

Oroville



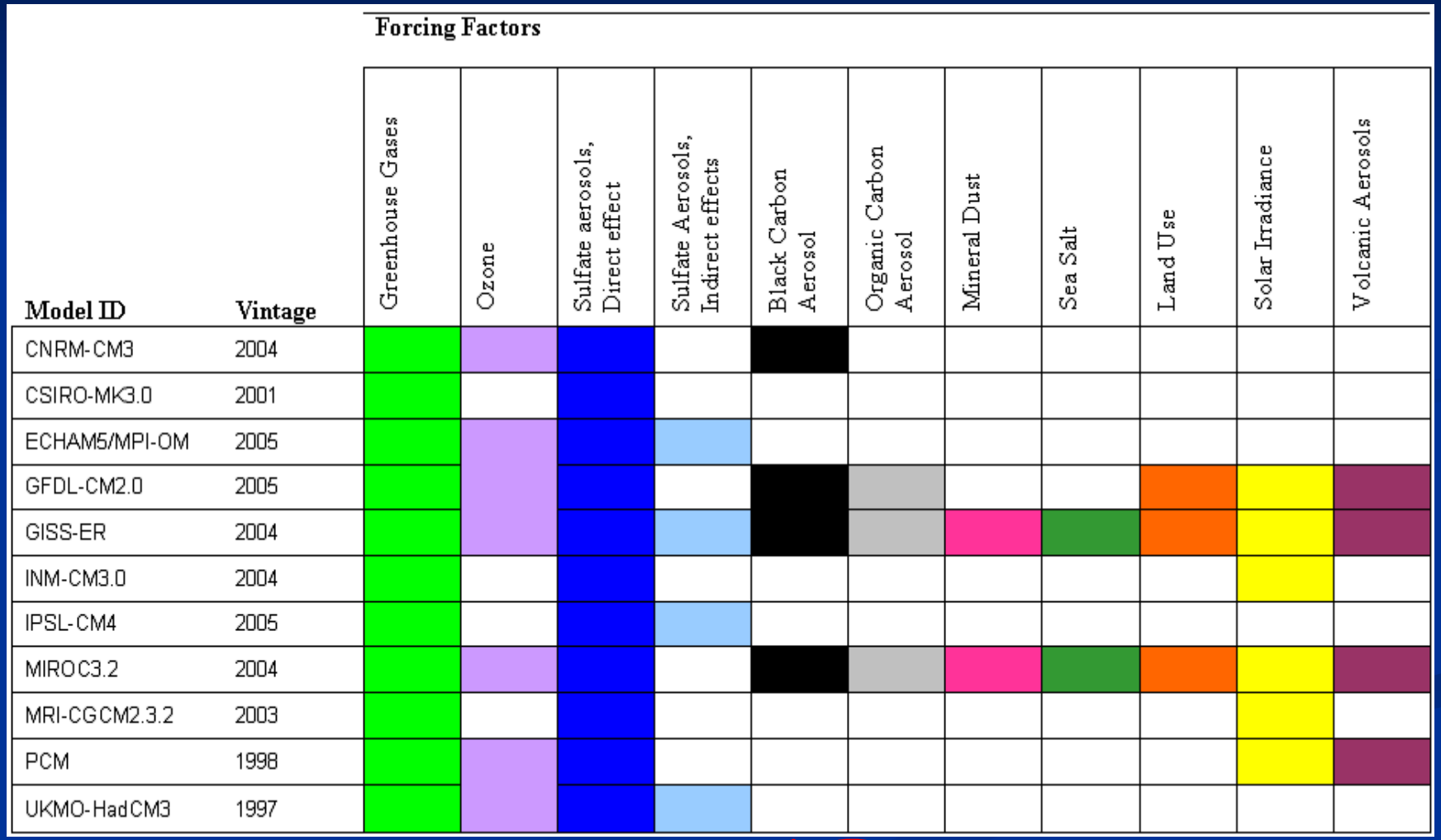
- Elevation range: 247-2820 m
- 50% between 1525-1980m
- Basin area: 932,914 ha
- Storage: 4.4 x10^9 m^3

New Bullards



- Elevation range: 556-2591 m
- 33% between 1525-1980m
- Basin area: 126,650 ha
- Storage: 1.2 x10^9 m^3

IPCC Climate models



Emission scenarios

	A2	B1
Associated green house gas (GHG) emissions	Significantly higher than present rate	Lowest of all GHG emission scenarios

2 scenarios x 11 climate models = 22 simulations

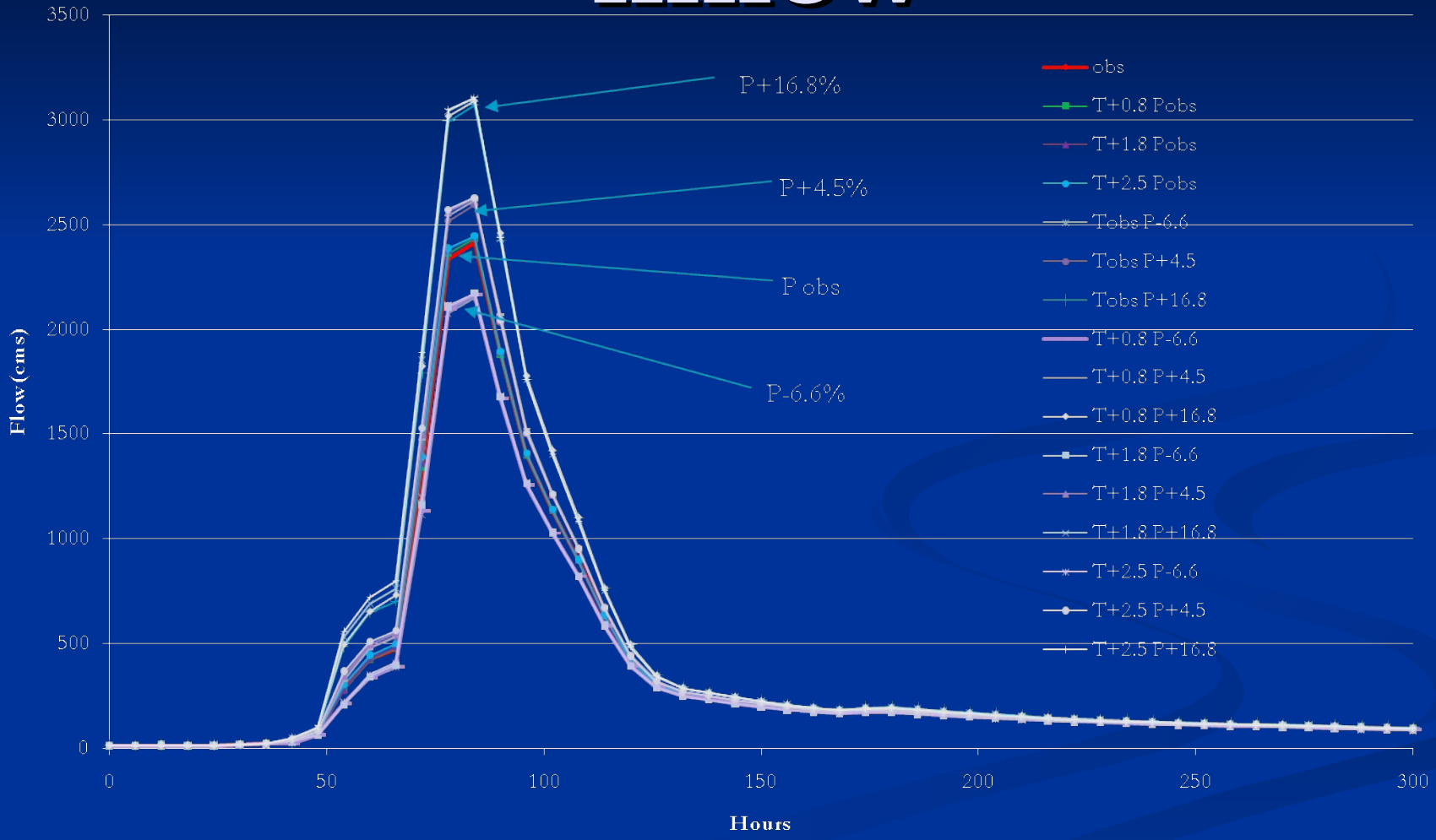
Temperature increases (°C)

		percentile values		
		10th	50th	90th
Shasta subbasins	**cnbc**	0.43	1.08	1.48
	pitc	0.41	1.05	1.42
	dltc	0.40	0.90	1.33
	mssc	0.41	0.94	1.37
	shdc	0.41	0.92	1.33
Oroville subbasins	**mrmc**	0.45	1.06	1.38
	ordc	0.43	1.01	1.34
	iifc	0.45	1.10	1.43
	plgc	0.43	1.03	1.35
	pllc	0.44	1.05	1.39
	ftcc	0.47	1.10	1.44
New Bullards Bar subbasin	**nbbc**	0.45	1.06	1.38
mean		0.43	1.02	1.39

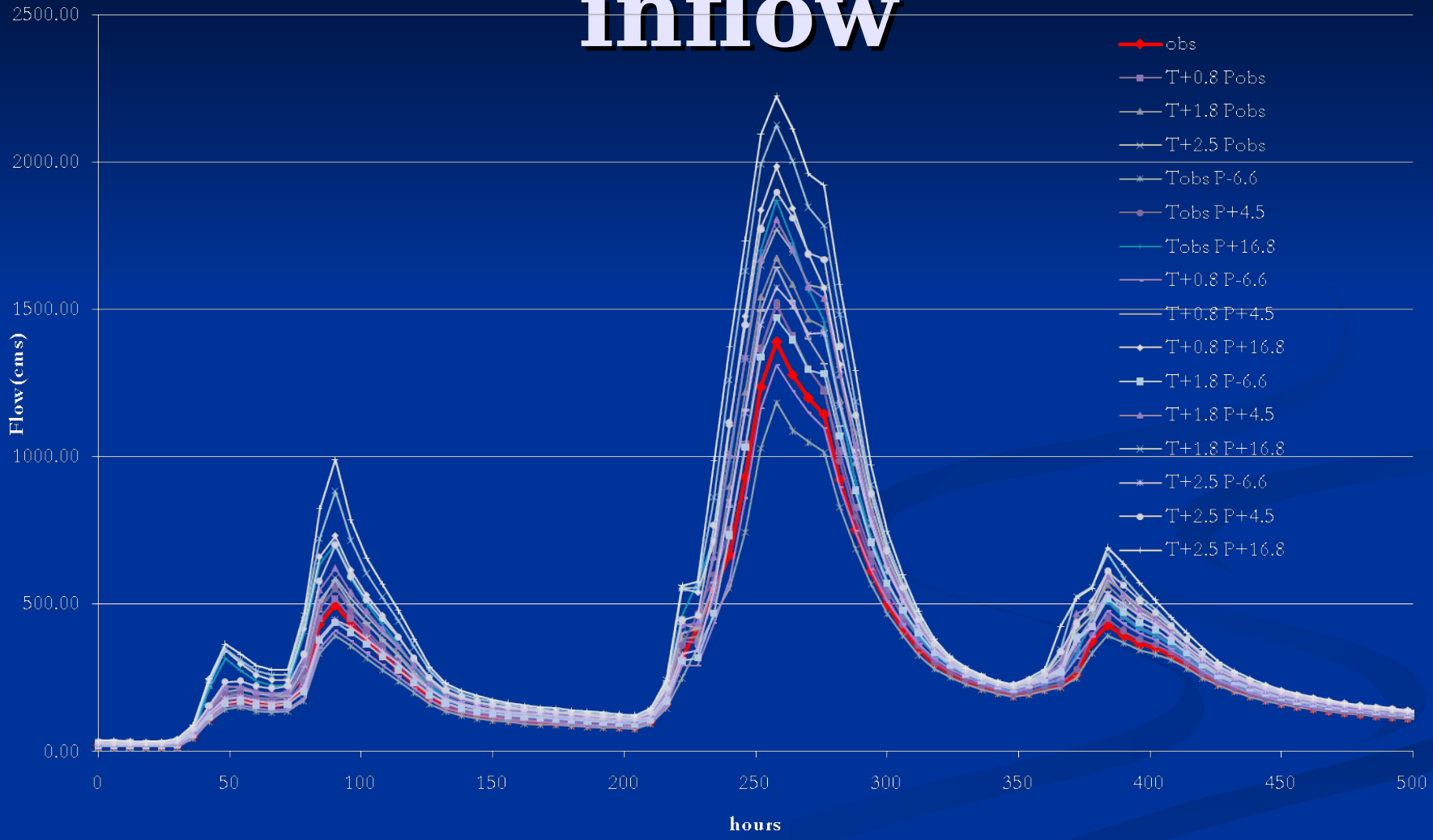
Precipitation change (%)

		percentile values		
		10th	50th	90th
Shasta subbasins	cnbc	-5.7%	4.8%	12.5%
	pitc	-5.7%	4.7%	15.5%
	dltc	-5.7%	3.7%	15.3%
	mssc	-5.7%	3.7%	15.2%
	shdc	-6.3%	3.9%	16.0%
Oroville subbasins	mrmc	-7.6%	5.2%	19.1%
	iifc	-7.1%	4.7%	18.5%
	ordc	-5.7%	3.7%	15.2%
	ftcc	-7.8%	5.1%	19.9%
	plgc	-7.1%	4.9%	17.7%
	pllc	-6.4%	4.4%	17.2%
New Bullards Bar subbasin	nbbc	-8.0%	5.0%	19.8%
mean		-6.6%	4.5%	16.8%

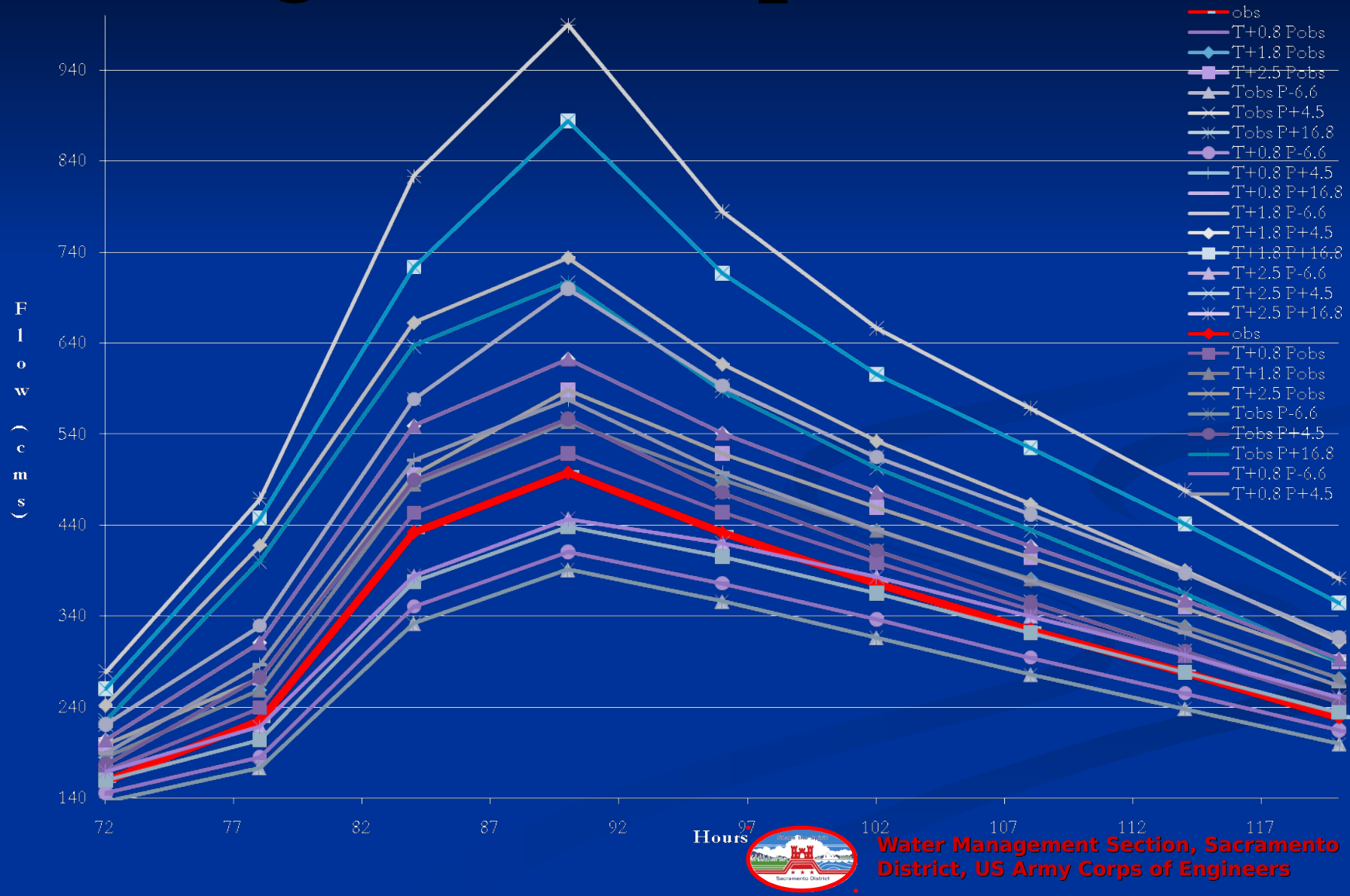
New Bullards Jan 1993 inflow



New Bullards Jan 1969 inflow



Jan 1969 peak 1



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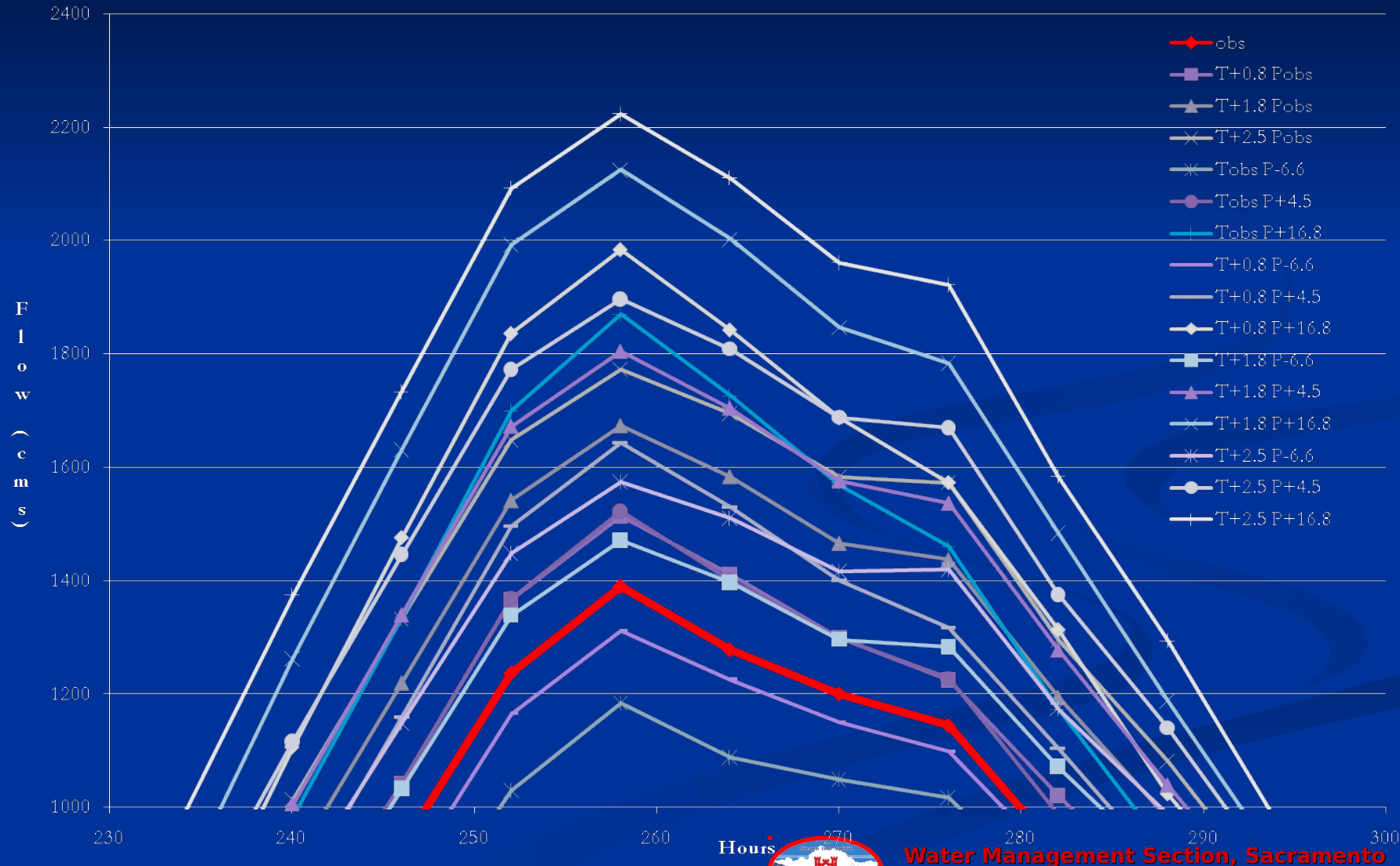
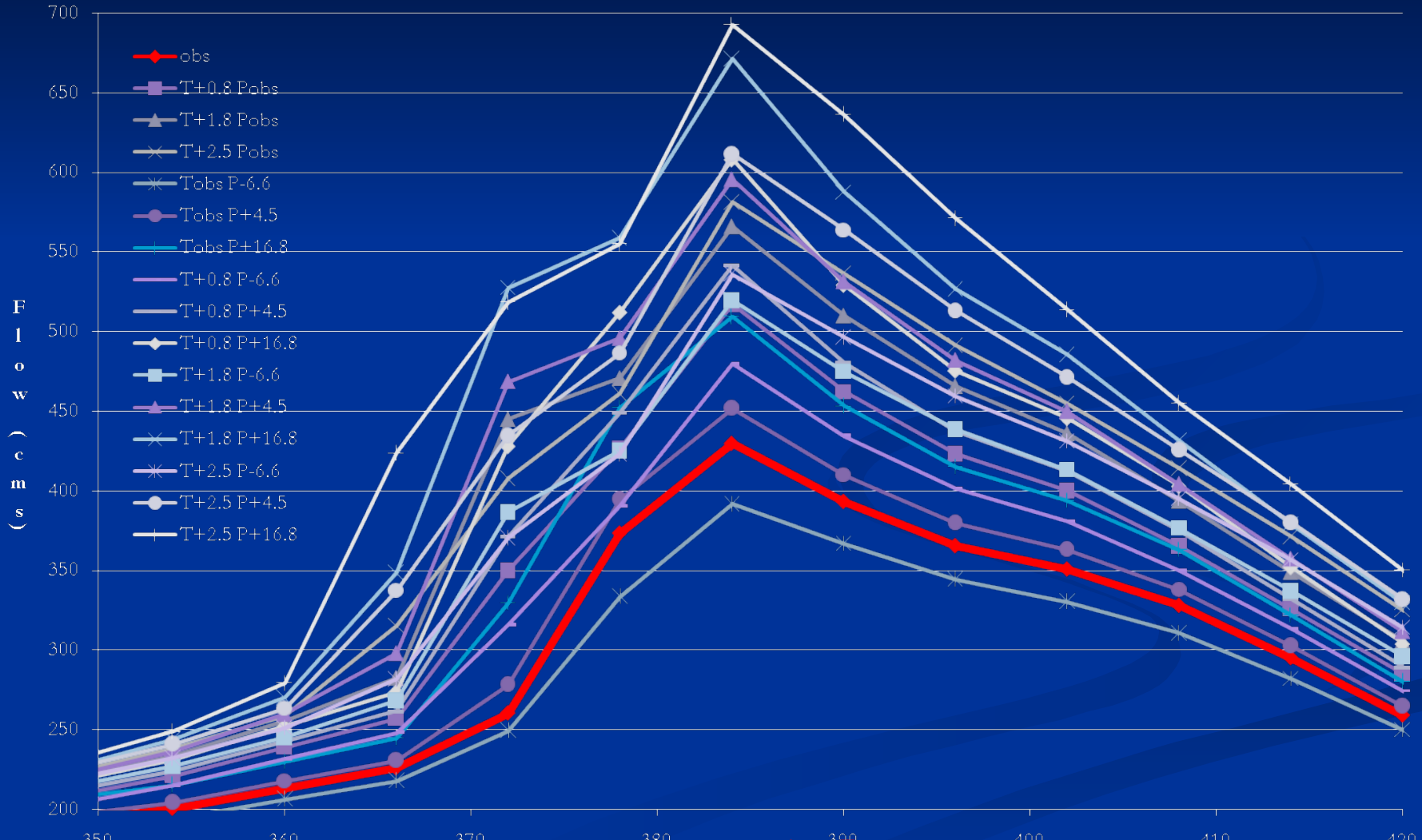
Jan 1969 peak 2



Water Management Section, Sacramento District, US Army Corps of Engineers

Jan 1969 peak 3



Water Management Section, Sacramento District, US Army Corps of Engineers

Still remaining

- Res-Sim modeling
- Examine event trends for flood risk reduction
  - Larger winter flood pool?
- Examine seasonal trends for water/power impacts
  - Allow earlier spring re-fill?

Acknowledgements

- Dr. Levi Brekke – Bureau of Reclamation
- Peter Fickenscher – California-Nevada River Forecast Center
- Dr. Beth Faber – Hydrologic Engineering Center